Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

aSB952
B75M47

Methyl bromide alternatives

USDA
NAT'L AGRIC LIBRARY
1997 FEB 27 P 11:05
CURRENT SERIAL RECORDS
ACQ/SERIALS BRANCH

Vol. 3, No. 1 January 1997

USDA

This issue and all back issues of the *Methyl Bromide Alternatives* newsletter are now available on the Internet at **http://www.ars.usda.gov/is/np/mba/mebrhp.htm**. Visit the ARS methyl bromide research homepage at **http://www.ars.usda.gov/is/mb/mebrweb.htm**.

Inside This Issue

Biologically Controlling Soilborne Pests: A Research Overview

For certain high-value crops like strawberries and tomatoes, many growers fumigate the soil to rid it of various soilborne root pathogens, harmful nematodes and weeds before planting their crops. In fact, approximately 80 percent of the methyl bromide produced in the United States is used to ready fields before planting. But with only four crop seasons left before the ban on methyl bromide is imposed in 2001, using alternatives to control these problems becomes increasingly more important.

"The most important pathogens to be controlled are those for which genetic resistance has not yet been identified, particularly those pathogens that can kill the plant," says Frank Martin. He is a plant pathologist at the ARS Crop Improvement and Protection Research Unit, Salinas, CA. "Two significant soilborne pathogens now controlled by methyl bromide and chloropicrin fumigation are verticillium wilt on California strawberries and fusarium wilt on Florida tomatoes."

Both these diseases, which can cause severe losses in a number of economically important crops, are caused by pathogenic fungi that infect a plant through the roots, move systemically through the plant, and ultimately kill it, Martin says.

While not as serious as the pathogens causing verticillium or fusarium wilt, damping-off and root-pruning pathogens cause types of diseases also controlled by fumigation. In damping-off, pathogens attack seeds soon after planting or attack roots of seedlings soon after transplanting. They rapidly take over the plant, causing death. Some of these same pathogens also can attack the roots of established plants, reducing root density which can stunt plant growth, vigor, and yield. The window of protection against plant death from damping-off can range from days to weeks; the sites needing protection are relatively small—the seed coat, the emerging root, or an early-developing root system. Because of the relatively restricted area needing treatment, it may be possible to add other microbes that inhibit disease to the seed coat or to the transplant plug before planting. Controlling pathogens with other microbes is referred to as "biological control."

Just what is biological control? "It is using microbes that are not detrimental to plants to protect them from microbes that are harmful," Martin says. "Some researchers expand this definition to include crop rotation because it causes changes in

This newsletter provides information on research for methyl bromide alternatives from USDA, universities, and industry.

Address technical questions to Kenneth W. Vick, USDA, ARS, National Program Staff, Bldg. 005, Room 237, BARC-West, 10300 Baltimore Ave. Beltsville, MD 20705. Phone (301) 504-5321, Fax (301) 504-5987.

Address suggestions and requests to be added to the mailing list to Doris Stanley, USDA, ARS, Information Staff, 6303 Ivy Lane, Room 444, Greenbelt, MD 20770. Phone (301) 893-6727, Fax (301) 705-9834.

soil microflora that can be detrimental to specific soil pathogens."

An example of a biological control agent is SoilGard™, a biofungicide developed from a common soilborne fungus by ARS scientists at Beltsville, MD, and commercialized by Thermo Trilogy, Inc. SoilGard™ protects vegetable and ornamental seedlings from soilborne pathogens.

Using the Pathogens Against Themselves

Plant pathologists Robert Larkin and Deborah Fravel have found several nonpathogenic strains of *Fusarium oxysporum* that control fusarium wilt in tomatoes, watermelons, and muskmelons. Located at the ARS Biocontrol of Plant Diseases Laboratory in Beltsville, MD, they have conducted greenhouse studies and plan future field tests at several locations.

"We found some strains of the fungi that actually induced resistance to the wilt, and others that controlled it through competition," Larkin says. "Strains that induce resistance are effective at much lower concentration rates than strains that work through competition. We've tested these potential biocontrol agents under a variety of conditions and in different types of soil and found them effective in all but the heaviest clay soil."

"On tomatoes, we've reduced fusarium wilt up to 90 percent and in watermelon and muskmelon, up to 80 percent," Larkin reports. "Although not as effective as the fungal biocontrol agents, several isolates of bacteria were also effective." They tested strains of *Burkholderia cepacia, Pseudomonas fluorescens,* and *Pseudomonas corrugata* and are investigating specific strains of the fungal antagonists *Trichoderma* and *Gliocladium*.

Larkin and colleagues are working to develop and improve the level and effectiveness of control of wilt diseases. "We feel that fusarium wilt diseases can be controlled biologically. With more research, these potential agents could be viable alternatives to chemical control for several crops," he says. More information on ARS research on biocontrol of plant diseases is available on the Internet (**http://www.barc.usda.gov/psi/bpdl/bpdl.html**).

An Integrated Approach to Root Health

"For vegetable crops in the Midwest and cereal crops in the Pacific Northwest, methyl bromide has never been a viable option for root health management," says ARS plant pathologist R. James Cook. "Virtually all crops grown without adequate crop rotation respond more or less the same to soil fumigation simply because all crops are subject to damage from their soilborne plant pathogens." He is based at the ARS Root Disease and Biological Control Research Unit in Pullman, WA. Jennifer Parke, plant pathologist with the University of Wisconsin, made a joint presentation on this research with Cook at the November 1996 methyl bromide conference in Orlando, FL.

Plenty of healthy roots make a plant better able to absorb fertilizer and water from the soil, Cook says. To get and keep good root health, he says the following principles must be considered.

1. Reduce, even if only modestly, the power of soilborne pathogens to cause disease.

This can be accomplished by starting the crop with pathogen-free planting material, avoiding fields known to be pathogen infested, allowing time for a natural decline of pathogens from crop rotation or by using soil solarization or short-term flooding.

2. Carefully manage the microenvironment of the soil where the pathogens are active to significantly reduce the severity of root diseases.

This type of management includes instituting practices that improve soil drainage, adjust temperature or water potential, and raise or lower soil pH, whichever produces an environment less favorable for the pathogen than for its natural enemies.

3. Introduce or foster naturally occurring biocontrol agents in the soil that surrounds roots through cultural practices or by incorporation with planting material.

Adding composts or other properly processed organic materials to the soil can make it inhospitable for some plant parasitic nematodes and some fungal pathogens, Cook says. Seeds and seedling transplants are ideal for introducing antagonists to biologically control specific pathogens because they allow the antagonist to be placed where it is most needed. And, the antagonist's growth can be supported by the plant it protects. Parke says that there are microbial inoculants on the market for use in the soil or on seeds and transplants to fight damping-off and root rots.

4. Target specific pathogens with narrow-spectrum fungicides applied with planting material or directly to the soil.

"Applied singly or as mixtures, selected fungicides like metalaxyl, difenconozole, triadimefon, propiconazole, and imazalil can control soilborne pathogens," Cook says. "But they must be applied so that they are taken up by the roots or come in contact with the pathogen."

5. Genetically increase the trait already present in plants to tolerate or resist virtually any biological or environmental plant stress factor, including soilborne pathogens.

Cook says that resistance has been found in plants to most, if not all, vascular pathogens such as *Verticillium dahliae* and *Fusarium oxysporium*, and to parasitic nematodes such as root knot and cyst.

"We're also finding useful resistance to pathogens in wild relatives of crop plants and although building in genetic resistance is a long-term approach, we're making progress," Cook reports.

California Strawberries: An Integrated Approach

Nowhere is the search for alternatives to methyl bromide more intense than in California's Pacific coastal valleys, from Monterey south to San Diego. For this is where about 80 percent of the strawberries grown in the United States come from. Here growers plant more than 23,000 acres of strawberries, valued at about $500 million a year.

"Over 99 percent of this commercial acreage is now fumigated with methyl bromide," reports Frank Sances. "This certainly increases the urgency in finding a replacement." As director of Pacific Ag Research near San Luis Obispo, Sances is trying several methyl bromide alternatives, including organic soil amendments and planting stock, called "plug plants." In addition to broccoli residues and spent mushroom compost, he is also using ozone-friendly fumigants on soil in field experiments. After 1 year of hard data from commercial strawberry fields and another year of data from intensive field trials on his 30-acre research farm on the central California coast, Sances reports some significant progress. Third-year field trials are under way.

"The progress we can report so far is not so much about a successful organic alternative as it is about the need for more information on how to work with previously fumigated soils," he says. "We found that organic growing techniques did not do well in soils that had been fumigated in successive years, cultivated, left unfumigated, and planted with the disease-susceptible strawberry varieties commonly used in California."

This scenario spells disaster for farmers regardless of how much they want to adopt nonchemical growing practices.

Sances tested alternative chemical treatments as well as promising organic mixtures of broccoli, high rates of compost, and then applied mycorrhizal bacteria to treated soil. The conventional alternatives obtained high fruit yields, he says, but the organic material could not regenerate the soil to the extent needed to suppress root pathogens and achieve commercially acceptable yields.

"Soil reconditioning takes time. Unfortunately, California strawberry growers cannot afford to take a 40 to 50 percent cut in yields until the soil can build up resistance to pathogens," Sances explains.

Repeated treatments with fumigants kill harmful, disease-causing organisms in the soil. But they also eliminate beneficial microorganisms and species complexity, and cause the soil to lose some of its ability to retain nutrients and water and resist erosion. For these reasons, Sances recommends adding additional organic matter and beneficial microorganisms to both fumigated and organic-supplemented fields.

Local strawberry growers cooperate in Sances' project to incorporate broccoli residues, mushroom compost, and a combination of both into the soil. They're also involved with testing three chemical alternatives—Telone/chloropicrin, Basamid, and metam sodium—with methyl bromide/chloropicrin (75/25) as a standard, and an unfumigated control. For these studies, 25 tons of both broccoli and organic compost were applied per acre.

"In fields treated with organic residues, weeding costs were five times more than in those chemically treated. The significant difference in weeds in these fields suggested that the organic matter probably added weed seeds to the system," Sances reports. "The cost to control weeds in unfumigated soil is a significant factor for organic strawberry growers. We have had to use black plastic mulch to limit weed growth and keep weed control costs to a manageable level. However, yields are not as high or as early as with conventional clear plastic."

As would be expected, yields were highest from the methyl bromide/chloropicrin, Telone/chloropicrin, and Basamid treatments. By season's end, soil treated with organic amendments

fared only slightly better than untreated soil, but diversity of the beneficial microorganisms increased. The problem with a first-year, single-application organic strategy is that yield was already reduced and root pathogens were already present in plant tissues late in the season when numerous beneficial organisms were active. Sances explains that strawberries, as well as most annual crops, need protection early in the season when plants are developing, flowering, and ready to bear fruit. Conventional fumigants work well because they're effective immediately after application early in the season, when root protection is most important.

"We've grown three successive cover crops on soil that is being used for the 1997 season in addition to adding high rates of compost and mycorrhizal innoculants. We planted strawberries when the levels of early-season beneficial microorganisms were highest, giving organic soil treatments the same advantage as chemical alternatives," says Sances.

Elaine Ingham, Oregon State University soil ecologist, collaborated on this research. For the 1995 field studies, they used a site that for 9 years had been fumigated repeatedly with methyl bromide/chloropicrin and planted with strawberries. Since these chemicals would have left very few beneficial microorganisms in the soil, it's not unusual that even high rates of compost and broccoli mulch didn't bring yields up to par.

Then in 1996, they tried the same treatments in soil that had lain fallow for 3 years and had never been planted to strawberries. Results were more encouraging: organic amendments produced yields that were only slightly lower than the methyl bromide/ chloropicrin standard.

For the next growing season, Sances is also using vigorous, disease-free strawberry plants produced in nurseries without methyl bromide/ chloropicrin. Called "plugs," these plants are grown in artificial potting mix instead of fumigated soil. Plugs have been used by Florida growers quite successfully for a few years.

Since he has used plugs for just one season, Sances says data are preliminary, but results indicate that they will work well in an organic production system. Yields from nonfumigated and composted soil were comparable to those from bare-root plants grown with methyl bromide, but more data are needed.

"We've gathered some valuable information from this research, but most importantly, we now know what doesn't work as an alternative way to grow strawberries on California's central coast," Sances says. "We now know that what we end up with will be a combination of organic and chemical methods to produce the nation's strawberries in the next century."

Soil Amendments Instead of Methyl Bromide?

Organic soil amendments, including animal and green manures and wastes from processed animal products like blood, bone, and fish meal, have been used as soil supplements for centuries.

However, one reason these organic materials have never been seriously considered as plant protectants is that there is no good way to evaluate their effectiveness, according to George Lazarovits, a plant pathologist with Agriculture and Agri-Food Canada. But, with the loss of methyl bromide looming in the near future, researchers are taking a closer look at these soil amendments.

"Growers have come to rely heavily on chemical fumigants, especially methyl bromide, because it controls such a wide range of pests and dissipates quickly to allow planting soon after treatment," he explains. "In lab and field tests, we found soil amendments good candidates to replace methyl bromide for eliminating certain soilborne pests."

Before the use of chemicals became so prevalent, soil amendments were recognized as a way to control soilborne diseases, Lazarovits says. In fact, when incorporated into the soil at 10 tons per acre, blood or fish meal has been shown to completely inhibit verticillium infection of tomatoes. And chitin, a substance found in the outer shell of crustaceans and insects and in the cell walls of many fungi, is registered as a nematicide.

"While an assessment of a chemical pesticide can be completed in a matter of hours, screening organic products or biological control agents requires weeks, even months," explains Lazarovits. "Not only are biological interactions complex and difficult to evaluate, their effects are more subtle than those of chemicals. And organic products must be tested in soil, which involves soil microbes, thereby further complicating the situation."

He and colleagues at the Pest Management Research Center in Ontario are working with feather meal and soymeal; meat, blood, and bone meal; hydrolyzed pig hair; fish byproducts; chitin; and manures from various animal sources and composts.

"We mixed various quantities of these products with soils from potato fields that had a history of scab and wilt. The products are nontoxic and most are edible," Lazarovits says. "Their effectiveness varies from soil to soil, likely because soil microbiology plays a crucial role in how each product degrades."

He found that in test plots planted with potatoes and tomatoes, soil amendments increased yields, reduced scab and wilt, and virtually eradicated plant pathogenic nematodes. Plants were greener, more vigorous, and survived the entire season, whereas plants in untreated soils died soon after emergence. Treated soils sprouted fewer broadleaf and grassy weeds.

"All treatments were somewhat phytotoxic for about 2 to 4 weeks, which only delayed plant growth in some cases, but was lethal for tomatoes. But in the second and third seasons after application, there was dramatic improvement in growth of tomatoes and potatoes," Lazarovits reports. "We found that potatoes tolerate treatment reasonably well in the first season if the supplements are applied the previous fall. We're investigating ways to control this residual phytotoxicity."

Effectiveness of an amendment to kill microsclerotia (fungal spores) produced by *Verticillium dahliae* depends on its nitrogen content and carbon-to-nitrogen ratio, and how it changes this balance in the soil. The amendments are ineffective in heat-sterilized soil, indicating that the active ingredients are the breakdown products, he says. To prevent production of active ingredients, both amendments and soil must be sterilized. There are enough microbes in untreated amendments added to sterilized soil to release active components, but it would take some time to be effective.

Amendments will usually kill microsclerotia in the soil within 7 to 10 days, when the soil is 75 °F, with 50 percent water-holding capacity, according to Lazarovits. He says that temperature is not critical; in fact, they got excellent results at 45 °F. However, soil moisture is important to efficacy; the amendments worked faster in drier soil.

How do these soil amendments kill harmful pathogens in the soil?

"Several mechanisms are at work, here," Lazarovits says. "The most successful products are those that raise soil pH temporarily to above 8.5 for a few weeks, after which it drops back to just slightly below what it was before treatment. Early on, volatile toxic gases, likely ammonia, from the compounds, quickly kill the fungal spores. Later effects are slower and probably involve biological control."

Unlike fumigation, which reduces overall numbers of soil microbes, soil amendments increase the total number of fungi and bacteria by up to 10,000 fold, but decrease the number of pathogens.

Lazarovits and colleagues are conducting further research to determine optimum concentrations of product required, timing and depth of application, cultural requirements, and longevity of protection.

Since large amounts of these products would be needed and amendments have variable efficacy depending on soil microbiology at different locations, one concern is the economics.

"We're looking at a thorough cost-benefit analysis. Granted, this system would be expensive and moving large quantities of these materials to the field would be difficult. However, we have developed a soil test that can be done in the lab prior to field application to see if a specific formulation will do the job required," Lazarovits explains. "A better understanding of how these amendments work will also help reduce the amount required in specific types of soil."

Alternatives for Quarantine Security

By law, the U.S. Secretary of Agriculture is authorized to enforce measures that prevent the introduction of exotic pests and plant diseases into the United States. Consequently, the United States, like most other countries, has regulations requiring that plants, plant products, and other regulated articles entering the country pose, at most, a minimally acceptable risk for introducing new or not widely distributed pests into the country. In many cases, the risk to quarantine security posed by a commodity is determined by USDA to be unacceptably high. Therefore, that commodity is denied entry unless the risk of pest introduction or spread can be practically and effectively eliminated by an approved treatment. This makes appropriate treatments vitally important to ensure safe agricultural trade.

For about 50 years, the United States has required that the efficacy of commodity treatments for certain pests, especially fruit flies, meet or exceed a Probit 9 statistical standard. To meet this standard, treatment must kill or sterilize 99.9968 percent of the

pests in a test of at least 100,000 individual pests. Although heat, cold and irradiation have limited uses as Probit 9 treatments, fumigation with methyl bromide is presently the most practical option for many commodities. Its loss will significantly affect the ability of the United States to manage the risk of introducing pests associated with exporting and importing agricultural commodities. Anticipating the loss of methyl bromide, USDA scientists from the Agricultural Research Service and the Animal and Plant Health Inspection Service (APHIS) are studying whether a less rigorous standard might be more appropriate for certain low-risk commodities.

"Probit 9 was adopted as a one-size-fits-all standard to provide adequate quarantine security for the highest risk commodities," says Kenneth W. Vick, ARS national program leader for postharvest entomology. "While this single standard has a long history of usefulness, given the ready availability of methyl bromide (and earlier, ethylene dibromide), it may now dictate an overly severe treatment for rarely or minimally infested commodities that have a very low probability of carrying exotic pests."

Historically, the Probit 9 standard was applied without considering the rate of pest infestation, the survival and reproductive capacity of the pest, or the effects of harvest, processing, and distribution on the pest's ability to survive and establish itself. No consideration is given to packaging and shipping conditions or to the season of shipment.

According to Vick, these factors are all important in determining the risk a particular commodity presents to the importing country.

"Our objective is to make the severity of the treatment proportional to the risk posed by the commodity," he says. "For many commodities, a less severe treatment is more appropriate, compared to the present standard. Recognizing that treatments may range in severity depending on the risk allows expanded use of controlled atmospheres, systems approaches, and other treatments which have not in the past met Probit 9 requirements. A less severe treatment means less commodity damage and longer shelf life."

Vick and ARS research entomologist Nicanor J. Liquido are working with APHIS to redefine the applications for Probit 9. Liquido heads the ARS Tropical Fruit and Vegetable Laboratory in Hilo, HI.

"In cases where the natural rate of pest infestation in the field is low and the chances of survival and reproduction are poor, the Probit 9 standard could be too stringent and therefore detrimental," Liquido says. "We're proposing a less severe treatment combined with modifications in packing, distribution, and inspection. The risk of pest survival and establishment would be based not only on quarantine treatment, but on biological, ecological, marketing, and distribution data as well."

He defines risk, in this case, as the probability of at least one reproductive pest being present in a particular commodity shipment.

"We'd welcome effective alternatives to the prescriptive requirements of Probit 9," says APHIS' Robert L. Griffin, who is in charge of APHIS' Risk Analysis Systems in Riverdale, MD. "We're seeking a more sophisticated definition of quarantine security based on pest risk. Most of the simple treatment solutions have been addressed over the past 40 years. The present need to identify alternatives provides a valid basis to evaluate increasingly more diverse and complex pest risk-management proposals. This requires working closely with our ARS counterparts to more precisely evaluate these proposals and consider whole systems, from production to consumption, rather than just postharvest."

This systems approach considers factors beyond simple treatment mortality in estimating the probability of live pests being present. A sliding scale based on pest risk, combined with a holistic approach, provides a much more versatile and technically valid way to evaluate whether a pest is present and how best to manage it, Griffin says.

"This increases the opportunity to identify new treatments and new approaches to treatment, which will result in improved ways to achieve quarantine security," he notes.

One new approach that APHIS is considering is to allow irradiation as a quarantine treatment for papaya, carambola, and litchi grown in Hawaii. While this treatment would provide for interstate movement of fruit, it would also protect other parts of the United States from Hawaiian pests.

"We're proposing several amendments to regulations that now govern irradiation procedures and facilities and the handling of treated and untreated fruits from Hawaii, Griffin reports.

Many Hawaiian-grown fruits and vegetables cannot be shipped to the U.S. mainland because of fear of introducing the Mediterranean fruit fly, the melon fly, and the Oriental fruit fly. Irradiation sterilizes these

pests. But, growers have been unable to ship irradiated papayas under existing regulations simply because there is no irradiation facility in Hawaii.

Griffin says that an amendment is being considered that will allow papaya, carambola, and litchi to be shipped from Hawaii for irradiation treatment at approved facilities on the mainland in areas where the fruit flies would not become established. At approved locations on the mainland, irradiation would mitigate the risk of any pest eggs or larvae reaching maturity and escaping from the fruit.

In addition to papaya, carambola, and litchi, the proposed regulation would potentially allow shipment of rambutan, atemoya, and other exotic fruits from Hawaii if they are free of other plant pests. Treatment efficacy other than Probit 9 may provide quarantine security for non-fruit-fly pests in these commodities.

"Some postharvest quarantine treatments designed to meet Probit 9 standards damage commodities to the point where they're unmarketable," Liquido says. "If a commodity is a poor host to a pest and can tolerate a treatment requiring a mortality rate lower than Probit 9, then it may be possible to export that commodity without any significant threat of introducing a new pest."

EPA and Pesticide Registration Issues

EPA is responsible under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) for determining that pesticides will not pose unreasonable risks to human health or the environment when used according to label directions. FIFRA also requires EPA to balance the risks of pesticide use against the benefits to society and the economy when allowing a particular use.

These registration decisions are based on EPA's review and evaluation of test data generated by the registrant in a variety of scientific areas, according to Paul Schuda. He is deputy director of EPA's Office of Pesticide Programs' Policy and Special Projects Staff. These general areas include toxicology and oncogenicity, ecological effects, environmental fate, and residue chemistry.

EPA may require as many as 90 to 100 specific tests in all of these areas and the manufacturer's cost for completing these tests can be up to $10 million. Industry has estimated that the total cost of a registration for all phases, from research and development through production, may exceed $50 million. And it can take from 9 to 10 years. Most pesticide registrations can cost significantly less than this, depending on their proposed uses; for example, a proposed use on cut flowers (enclosed areas; not food uses requiring tolerances) will probably cost less than a use for corn or soybeans (many acres; food crops).

"And the specific scientific studies required are determined by the proposed use of the pesticide. Furthermore, if the proposed use is on a food crop, the registrant must petition the agency to establish a tolerance, or maximum residue level," Schuda explains. "Because of these critical and sensitive cost and timing factors, the amount of data required becomes a sensitive issue also."

Three sets of documents describing the tests are available: 40 CFR Part 158 describes which tests are required, the Pesticide Assessment Guidelines give detailed guidance for how the tests may be performed, and the Standard Evaluation Procedures (SEP's) describe how the scientific reviewers at EPA evaluate test results for use in risk assessment.

"If someone wants to get a pesticide registered at EPA, the first step should be a preregistration conference where the potential registrant visits EPA to get the information and forms necessary to process the application," Schuda says. "This conference informs the registrant of scientific and technical data needed to support the registration for the proposed specific uses, and answers questions about EPA's review and decision-making processes."

After this conference, the registrant develops the required data and submits it to EPA, along with an application to register the product, draft labeling, and a tolerance petition (if the proposed use is for a food crop). The scientific information is reviewed and sometimes questions are raised that require the interaction and meeting of scientific and management personnel from both parties. Additional information may be needed, studies may need to be repeated, or additional studies may need to be conducted and new data submitted. After issues are resolved, the risk and benefits assessment portions of the process are completed and forwarded to the decision maker. Keeping in mind the proposed use of the pesticide, risk managers evaluate assessment results and make a decision based on risks versus benefits. During the decision-making process, EPA may require changes in proposed labeling, uses, and application methods to mitigate risks to human health or the environment.

Each year EPA makes a large number of various types of regulatory decisions. In 1996, those included:

New Chemicals (active ingredients)	24
New Uses for existing chemicals	122
Old Chemicals [similar chemicals/uses ("me-too's")]	912
Label Amendments	3,290
Experimental Use Permits	102
Special Local Needs [Section 24(c)'s]	373
Emergency Exemptions (Section 18's)	452
Tolerances	141
Total	5,416

An example of the magnitude of EPA's responsibilities concerning pesticides is the 1995 figures, which indicate 610 active ingredients currently in production and 19,000 formulated pesticide products registered for marketing and use in the United States.

Another part of EPA's mandate is to bring the scientific databases of registered pesticides up to current standards through the reregistration process. As pesticides pass through this process, modifications may need to be made to registrations, labels, and tolerances to protect human health and the environment. This has become a very resource-intensive undertaking. Since 1991, EPA has made Reregistration Eligibility Decisions on 201 of the 382 chemical cases (53%), meaning that these active ingredients may proceed through the product-specific reregistration phase in which each formulated product is registered again according to its use. The remaining 181 chemical cases (47%) are projected to complete product specific registration by the year 2004.

Registration Questions:
Conventional Chemicals
EPA Contact: Registration Division, (703) 305–5447

Registration Questions:
Biopesticides
EPA Contact: Biopesticides and Pollution Prevention Division, (703) 308–8128

Registration Questions:
Antimicrobials
EPA Contact: Antimicrobials Division, (703) 305–5440

DiTera®: Controlling Nematodes Biologically

Microscopic worms called nematodes are a problem for many crop producers. Nematodes, found in soil, cause significant reductions in yield and quality of produce. Feeding by nematodes damages the plant by affecting nutrient absorption and providing infection sites for a wide range of secondary plant pathogens. Root-feeding nematodes have also been found to transmit viral diseases.

Traditionally, the most common means of controlling nematodes have included soil fumigation with Telone® and methyl bromide, and application of nonfumigant nematicides such as organophosphates and carbamates. In 1987, researchers at Abbott Laboratories discovered DiTera® (formerly known as ABG–9008), an environmentally compatible, biological alternative to chemical nematicides for the suppression of plant nematodes.

"DiTera® effectively controls several economically important nematode species, including root knot (*Meloidogyne* spp.), cyst (*Heterodera/ Globodera* spp.), lesion (*Pratylenchus* spp.), stubby root (*Trichodorus* spp.), sting (*Belonolaimus* spp.), burrowing (*Radopholus similis*), and several others that attack various crops. It kills nematodes in the soil on contact," says Prem Warrior, manager of agricultural microbiology, Chemical and Agricultural Products Division at Abbott Laboratories, Long Grove, IL.

DiTera®, a natural product from the hyphomycete fungus *Myrothecium* spp., is composed primarily of proteins, sugars, and lipids and is stable under heat and environmental rigors. "Researchers here at Abbott Laboratories, along with university researchers and university cooperative extension personnel, tested the efficacy of DiTera® through various levels of laboratory, growth chamber, greenhouse, microplot, and field studies over the past 9 years. At this point, DiTera® has been tested primarily on vegetable crops, including carrot, cauliflower, egg plant, and squash, though studies on perennial crops such as grapes and citrus are under way," says Warrior.

Field evaluations on carrots conducted in Bakersfield, CA, showed that root-knot nematode galls were reduced to significantly lower numbers when treated with DiTera® at 60 pounds per acre 1 week prior to emergence, compared with untreated controls. These results were statistically comparable to the recommended dosage of methyl bromide at 200 pounds per acre. In this same experiment, methyl bromide applications gave 55 percent marketable carrots, compared to DiTera® at 53 percent, while the untreated crop yielded only 40 percent. Typically, without adequate nematode protection, carrot yields in this major carrot-producing area can be as low as 20 percent. Several trials

on carrots, cole crops, and grapes have been completed to date and the results have been very encouraging in terms of nematode control and crop yield response.

"In field tests we've conducted so far, we found that DiTera® suppressed all plant nematode populations in the soil and roots. It has no nematicidal activity against free-living nematodes, those which feed on soil micro-organisms. Reduced numbers of nematodes in the soil and roots were noted at a use rate of 25 to 100 pounds per acre, depending on the crop, soil type, and nematode species," Warrior says. "In addition to its direct nematicidal activity on juvenile and adult nematodes, applications of DiTera® can also possibly modify the rhizosphere microbiology. This could increase the number of natural predators, alter the carbon/nitrogen ratio of soils, and increase the levels of ammonia around the root zone of plants, resulting in overall suppression of nematodes. DiTera® provides economic suppression comparable to nonfumigant chemical nematicides."

DiTera® is available as spray-dried powder (average particle size 40 microns) produced by fermentation and is known as DiTera® WP. A liquid formulation, DiTera® ES, is an emulsifiable suspension containing 27.5 percent active ingredient. A granular product, DiTera® G (95 percent) is under development.

DiTera® ES is applied directly on the soil surface as a suspension in water either as a preplant treatment in the rows or at planting, emergence, or immediately after transplanting. The granular or powder formulations can be sprinkled around the root zone and incorporated into the soil either mechanically or with water prior to planting. Field evaluations at Abbott Laboratories show a single application at the recommended rate will suppress nematode populations and protect young seedlings in the soil. However, multiple applications may be required for high nematode populations and on perennial crops. DiTera®'s effectiveness may be altered in soils with high organic matter content, especially those containing infected plant roots from previous crops. As is typical for other soil-applied products, the specific recommendations need to be based on the crop, soil type, biology of the pest, and a variety of other factors.

"At the recommended rates of application to soil, we haven't found any phytotoxicity on any of the crops we've tested. DiTera® has the minimal re-entry interval and waiting period (4 hours) required by law for any pesticide," says Warrior. "We're still compiling data to test the compatibility of DiTera® with other soil pesticides and also fine-tuning effective methods to deliver this product to target sites."

After extensive evaluations on its toxicology profile, EPA exempted DiTera® from a requirement of tolerance on all agricultural commodities and granted unconditional registration for its use on a variety of crops in the United States. Earlier this year, the product was approved for use in several states including California, Florida, and Texas, and it has been registered for use in Chile. A stability test conducted to meet EPA's requirements for product registration showed DiTera® did not lose its nematicidal activity even after 24 months of storage at room temperature (72 °F). DiTera® also offers the flexibility of pre- or postplant applications.

Abbott Laboratories holds U.S. patent no. 5,051,255 and several foreign patents on DiTera®, and plans to have it available in selected agricultural markets in early 1997. Once fully developed and commercialized, it could fill a long-awaited niche in the area of environmentally compatible biorational alternatives to chemical nematicides. DiTera® is not a replacement for methyl bromide; it is a specific nematicide that provides suppression of plant nematodes with minimal impact on the environment or other organisms.

"In combination with other pesticides, such as herbicides and fungicides, DiTera® can be an effective component in our overall attempt to find an alternative. The scientific community is skeptical about finding a silver bullet that will replace methyl bromide. Our efforts will be targeted toward developing DiTera® as an effective component of an integrated pest management system to improve crop productivity," says Warrior.

Steam Treatment for Waste Wood

Wood packing is used in importing bulk goods into the United States to prevent shifting during ocean travel. Under regulation 7 CFR 319.40–Importation of Logs, Lumber, and Other Unmanufactured Wood Articles–the Port Operations Unit of USDA's Animal and Plant Health Inspection Service quarantines solid-wood packing materials that could potentially harbor plant pests. The wood packing is either fumigated with methyl bromide or heat treated at 71.1 °C for 75 minutes.

"Fiber Fuel International is developing a steam sterilization process as a methyl bromide alternative to fumigation of quarantined wood waste from

shipment packing," says Glenn White, project manager with Fiber Fuel International, Inc. (FFI) in Savannah, GA. "We have several goals for this project. Not only will this be one alternative to methyl bromide fumigation, but it will also save landfill space by recovering imported wood waste. This recovered wood will be a clean, low-cost feedstock for biofuel and renewable energy products."

Sometimes, during the process of unloading the imported articles, the wood is broken or damaged and is not reusable. The ships store the broken wood on board, until they can dump it into the ocean. However, MARPOLV, a U.S. and world maritime regulation, charges penalties for dumping wood waste within 25 nautical miles of shore. Offenders could receive a fine of up to $500,000 and 6 years' imprisonment.

"Dumping the wood into the ocean is not an alternative. This dumped wood has washed up on our shores, littering beaches and ecologically fragile barrier islands. Floating wood waste causes safety problems for fishing boats off the coast of Savannah, GA," says White.

This project to use steam to sterilize quarantined waste wood is a partnership between FFI and two Swedish firms, Winbergs and NYPRO. A prototype of the Swedish steam sterilization vessel, tested and approved by USDA, was found effective in destroying plant pests. During the sterilization process, the wood goes through a grinder and is then conveyed to an enclosed bin where the chips are metered by volume into the steam sterilizer and treated at 105 °C at 0.5 bar pressure for 5 minutes. This process successfully kills pests in the wood. (For more information, see David Dwinell's technical report, "Alternatives to Methyl Bromide for Eradicating Pests in Exported Softwood Chips, Lumber, and Logs," in the October 1996 issue of this newsletter.)

The steam sterilization vessel is about 10 meters long and 2 meters in diameter, and has butterfly valves with stuffing glands at each end to ensure atmospheric integrity. A chain-plate conveyor acts as a treatment table and as a chip carrier inside the vessel. Steam is directly injected into the vessel through a multiport manifold directly onto the wood chips, resulting in sterilization with reduced moisture content.

"The sterilized wood chips can be used in our patented fuel process for cofiring wood with pulverized coal in utility boilers or in smaller boilers that need to use a cleaner fuel than is presently being used. Cofiring wood with coal reduces the pollution produced from the burning of coal," says White.

If USDA certifies development and testing of the equipment and sterilization process, FFI will market the licensed process to shipping ports and waste recovery companies throughout the United States. Of about 79 ports monitored by USDA, about half are now using methyl bromide on quarantined wood waste.

"The fumigated wood is placed in landfills or can be used as mulch. In the future, our steam sterilization process can make quarantined wood waste into a clean, renewable fuel," says White.

USDA's Oxford Plant Protection Center in North Carolina is examining a compliance agreement for this alternative to methyl bromide. This project is supported by the Southeastern Regional Biomass Energy Program, which is administered by the Tennessee Valley Authority for the U.S. Department of Energy.

Technical Reports

Research on Alternatives to Methyl Bromide for Control of Nematode Pests of Stone Fruits

Andy Nyczepir, Research Nematologist, and Tom Beckman, Research Horticulturist, Southeastern Fruit and Tree Nut Research Laboratory, USDA, ARS, Byron, GA 31008; and Greg Reighard, Associate Professor, Dept. of Horticulture, Clemson University, Clemson, SC 29634.

Guardian™ rootstock, developed by USDA–ARS and Clemson University, shows promise as an alternative to preplant fumigation with methyl bromide for peach orchards.

The Southeast is a major producer of fresh peaches in the United States. A combination of favorable climate, soil type, and market availability has greatly contributed to the successful production of this stone fruit. Even though the Southeast is noted for being a leader in fresh peach production, the total number of trees has decreased drastically over the past 50 years for a number of reasons, one of which includes the presence of nematode pests. It is estimated that each year Georgia loses about 66,000 bearing trees and South Carolina, 87,000, to peach tree short life alone.

Two nematode pests of concern that are associated with reduced peach tree survival and productivity in the Southeast are the ring (*Criconemella xenoplax*) and root-knot nematodes

(*Meloidogyne* spp.). The continuous presence of the ring nematode in conjunction with poor management practices makes peach trees more susceptible to cold injury and bacterial canker, two important agents responsible for sudden tree death commonly referred to as the peach tree short life (PTSL) disease complex. Peach trees parasitized by the root-knot nematode, on the other hand, are often stunted in growth during the first 2 years after planting, thus reducing tree vigor. Both nematode pests are widely distributed throughout the peach production areas of the Southeast and continue to be a problem if not aggressively managed. Methyl bromide is one of two preplant nematicides recommended for managing these nematode pests. Furthermore, when both nematodes are present and PTSL is a concern, growers are encouraged to plant trees on Lovell rootstock, even though this rootstock is susceptible to root-knot nematode. Recently it was demonstrated that the interaction between these two nematodes caused a significant reduction in Lovell tree growth as compared to either nematode alone.

At USDA–ARS and Clemson University, scientists are working cooperatively and independently on development of alternatives to preplant fumigation with chemical nematicides. One nonchemical alternative is the development of peach rootstock resistance to nematode pests. A rootstock superior to Lovell that survives longer on PTSL sites and also resists root-knot nematode would be of great value to the peach industry.

A peach seedling rootstock (BY520–9), identified in 1991 as providing greater tree survival than Lovell in PTSL sites, is now commercially available under the trade name of Guardian™. In early tests, Guardian™ rootstock also appeared to have some resistance to root-knot nematodes, although industry demand has resulted in commercial availability of Guardian™ before all root-knot nematode testing was completed. Currently, the USDA and Clemson University are providing commercial nurseries with seed of Guardian™ collected from a group of BY520–9 selections. These selections are all siblings. The mother tree was lost before BY520–9's superior field survival was discovered. One unanswered question about commercially available Guardian™ rootstock from the USDA and Clemson seed sources is whether it is a suitable host for root-knot nematodes, especially the Southern (*M. incognita*) and Javanese (*M. javanica*) species.

In 1995–96, studies were initiated to determine the susceptibility of Guardian™ rootstock to *M. incognita* and *M. javanica*. Results indicate that both commercial seed sources of Guardian™ are poor hosts to the two root-knot nematode populations tested. For both root-knot nematodes, reproduction was less on both Guardian™ sources than on Lovell. However, it should be noted that galls form on roots of trees from both Guardian™ seed sources, and, in fact, *M. incognita* produced just as many galls on Guardian™ as on Lovell. The major benefit of Guardian™ rootstock is that root-knot nematodes do not reproduce well even though galls are formed. Thus, evaluating rootstocks for resistance to root-knot nematode should not solely be based on a root-galling index. Root penetration and development of *M. incognita* on Guardian™ and Lovell seedlings at 3, 6, 12, and 24 days after inoculation were also followed. *M. incognita* infective stage juveniles penetrated Guardian™ roots, root galls formed, but the majority of the nematodes did not complete their life cycle.

Further investigations are needed to evaluate the host suitability of Guardian™ rootstock against additional isolates of *M. incognita* and *M. javanica* and other root-knot nematode species to determine just how broad and effective its resistance is.

Prunus Rootstock Breeding for Nematode Resistance

Craig Ledbetter, Research Geneticist, Horticultural Crops Research Laboratory, Postharvest Quality and Genetics Research Unit, USDA, ARS, Fresno, CA 93727–5951.

In instances where parasitic nematode infestations are the sole problem in a selected orchard site, nematode-resistant rootstocks may be a viable alternative to pre-plant methyl bromide fumigation.

Nematode resistance is recognized worldwide as an important *Prunus* rootstock breeding objective. It is fortunate that root systems of *Prunus* are attacked by relatively few of the many plant parasitic nematodes. Three genera of nematodes are generally recognized as causing economic damage in stone fruit orchards. These include the root knot nematodes (*Meloidogyne* spp.), root lesion nematodes (*Pratylenchus* spp.) and ring nematode (*Criconemella xenoplax*). These nematodes can occur alone, or in mixed populations in the upper soil profile. Symptoms of nematode attack include early defoliation, reduced fruit yield, stunted tree growth and early tree death. Plant parasitic nematodes are a primary reason for pre-plant methyl

bromide fumigation of new orchard soils or for spot fumigation of replant sites.

Prunus breeders have been occupied with the development of nematode resistant rootstocks for decades. 'Marianna 2624', a clonally propagated plum rootstock with root knot nematode resistance, was introduced in 1940. 'Nemaguard' and 'Nemared', two seed-propagated root knot nematode resistant peach rootstocks, were introduced in 1959 and 1983, respectively. Numerous other root knot resistant rootstocks, both clonal and seed propagated, have been developed and are being utilized in a variety of orchard environments. Breeding for root knot nematode resistance in *Prunus* is facilitated by the visually striking symptoms on susceptible *Prunus* root systems. Furthermore, the resistance is genetically dominant to susceptibility. These two factors allow for relatively easy breeding and selection of new germplasm with resistance to root knot nematode.

The relative ease of breeding for resistance to root knot nematode is a stark contrast to the difficulty involved in the development of resistance to ring nematode. Screening efforts to identify resistance to ring nematode in *Prunus* have been unsuccessful to date. Over 400 genetically diverse accessions of *Prunus* have been evaluated and all appear to support ring nematode reproduction. Among these screened accessions were many root knot nematode resistant rootstocks. These evaluations point out that resistance to nematodes in *Prunus* is both genera and species specific. Therefore, new rootstock accessions must be challenged with each specific nematode species, race, or population for a determination of resistance or susceptibility.

At the USDA/ARS Horticultural Crops Research Laboratory in Fresno, CA, we have screened over 200 diverse *Prunus* accessions to identify root lesion nematode (*Pratylenchus vulnus*) resistant germplasm. Resistance to root lesion nematode has been identified in a few genetically diverse *Prunus* accessions. Whether or not these root lesion nematode resistant accessions will be acceptable as rootstocks remains to be clearly demonstrated. Rootstock acceptability is based on many factors, including rootstock performance in the nursery. The ability to root and growth characteristics of the rooted cuttings may influence a nursery person's choice of whether or not to propagate new rootstock accessions. Rootstock vigor, either lacking or excessive, tree anchorage, water use efficiency and fruit production potential are all critical characteristics which a fruit producer might want knowledge of prior to investing in a newly recommended rootstock. Furthermore, graft compatibility between the rootstock and the fruit-bearing portion of the tree must be demonstrated for all new candidate rootstocks.

We are currently examining some of the important rootstock characteristics of the root lesion nematode resistant germplasm. Since root lesion nematode is known to inhabit the same orchard soils as root knot nematode, we have screened the root lesion nematode resistant candidate rootstocks against root knot nematode. Many of these *Prunus* candidate rootstocks effectively resist the root knot and root lesion nematode populations endemic to California. Initial graft compatibility of the candidate rootstocks has been demonstrated with apricot and French prune at our Fresno location. We have also evaluated rooting ability and growth characteristics of rooted cuttings. Our results demonstrate that several candidate rootstocks have rooting abilities and growth characteristics similar to the commercial *Prunus* rootstock 'Marianna 2624'.

We are currently expanding our evaluation efforts through large-scale trials. In 1997, nursery industry personnel will be examining the candidate rootstocks from a commercial perspective. In addition to rooting and nursery performance, our evaluations will include graft compatibility of candidate rootstocks with almond, nectarine and peach. As trees come into bearing, fruit production characteristics will be compared with similar trees grown on standard commercial rootstock cultivars. It is only after these large-scale evaluations that we will be able to make recommendations regarding the use of new root knot and root lesion nematode resistant candidate rootstocks.

Alternatives to Methyl Bromide for Disinfesting Equipment Contaminated with the Golden Nematode

Bill B. Brodie, USDA, ARS,
Department of Plant Pathology,
Cornell University, Ithaca,
NY 14853.

Since the establishment of the golden nematode regulatory program in 1944, methyl bromide applied at 240 g/m^3 for 24 hours under polyethylene has been the treatment of choice for disinfesting equipment and other articles to free them of the golden nematode. This treatment is used routinely to decontaminate articles that are moved from golden nematode-regulated areas to nonregulated areas. Because of the effectiveness of methyl bromide,

there has been essentially no effort to develop other types of treatments. However, the impending phaseout of methyl bromide has forced the development of a more environmentally compatible treatment to ensure the integrity of the golden nematode quarantine.

High temperature has the greatest potential as an environmentally safe alternative to methyl bromide for disinfesting items contaminated with the golden nematode. We have found that golden nematode eggs in cysts that had been presoaked in water for 24 hours are killed when exposed to 55 °C for as little as 30 seconds. In contrast, eggs in dry cysts tolerated temperatures as high as 75 °C for brief periods.

Steam is a common source of heat used to sterilize soil and other items but it has not been used as a treatment to disinfest equipment contaminated with the golden nematode. However, high steam is used to clean soil from golden nematode-contaminated equipment, but the direct effect of this procedure on survival of nematode eggs is not known. In initial studies to develop an alternative treatment to methyl bromide, solarization with or without supplemental heat looked promising as a lethal treatment against the golden nematode. We found that when cysts were soaked in water prior to the solarization treatment, only 4 percent of the eggs survived. Furthermore, the juveniles from these eggs failed to infect potato plants. When supplemental steam heat was added, only 1 percent of the eggs survived, and their resultant juveniles failed to infect potato plants.

In further experiments, we tested different types of heat treatments against the golden nematode. The heat treatments consisted of solarization (sealed in clear polyethylene for 28 hours and exposed to direct sunlight), solarization plus supplemental steam heat, and solarization plus supplemental dry heat. Soil containing 20 golden nematode cysts in nylon sackettes was placed in small crevices of tillage equipment. The equipment was either left dry or washed with high pressure water to wet the cysts and increase the humidity. The equipment was sealed in clear polyethylene for 28 hours and supplemental heat was applied for 6 hours on each of 2 days. Methyl bromide applied at 240 g/m^3 under black polyethylene for 28 hours served as a control. The check consisted of cysts contained in nylon sackettes that were not subjected to treatment.

After the treatments were completed, the sackettes were retrieved and the cysts were subjected to a hatching test. The hatching test consisted of soaking the cysts in water for 5 days then placing them in potato root exudate for 3 weeks. The number of juveniles that emerged was counted weekly and fresh exudate was added. An average of 78 juveniles/cyst hatched from the nontreated cysts. Hatch from cysts subjected to the standard methyl bromide treatment averaged 0.6 juveniles/cyst. Hatch from cysts subjected to supplemental steam heat averaged 0.07 juveniles/cyst when the equipment was not prewashed with high pressure water and 0.18 juveniles/cyst when the equipment was prewashed to wet the cysts. Hatch from cysts subjected to supplemental dry heat averaged 69 juveniles/cyst when the equipment was not prewashed and 25 juveniles/cyst when the equipment was prewashed. Hatch from cysts subjected to solarization without supplemental heat averaged 56 juveniles/cyst when the equipment was not prewashed and 25 juveniles/cyst when the equipment was prewashed.

In all treatments, some nematode eggs appeared to survive, but they did not hatch in response to potato root exudates. The numbers of viable eggs that did not hatch included 47 eggs/cyst from the untreated control, 0.7 eggs/cyst from the methyl bromide treatment, 1.2 eggs/cyst from the steam heat treatment, 31 eggs/cyst from the dry heat treatment, and 30 eggs/cyst from the solarization treatment. These eggs have been placed around the roots of potato plants to determine the infectivity of the resultant juveniles.

These tests indicate that solarization treatment alone in the northeastern United States is not sufficient to disinfest equipment contaminated with the golden nematode. Although prewashing equipment with high-pressure water increased the sensitivity of golden nematode eggs to high temperatures, it was not enough to achieve the desired amount of nematode mortality. Lethal temperatures were achieved with supplemental dry heat under polyethylene but because the eggs were desiccated, nematode mortality was minimal. Nematode mortality with supplemental steam heat equaled that achieved with methyl bromide, suggesting that steam heat is a suitable alternative to methyl bromide for disinfesting equipment contaminated with the golden nematode.

USDA Perspective on Methyl Bromide

Third Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction, Orlando, Florida, November 4–6, 1996

Edward B. Knipling, Acting Administrator, Agricultural Research Service, USDA

Good morning. I'm honored to be here this morning representing ARS Administrator Floyd P. Horn who has been asked by Secretary Glickman to be the Acting Deputy Under Secretary for Research, Education and Economics until the new Administration is in place. In turn, Dr. Horn asked me to serve as Acting Administrator for ARS. Dr. Horn sends his personal regrets for not being here and asked that I express his appreciation for the opportunity for ARS to again co-sponsor, with the Crop Protection Coalition and the EPA, this international conference to discuss our search for methyl bromide replacements.

Today, I want to provide a brief USDA policy perspective on methyl bromide alternatives and to describe some of our research activities underway.

Problem Defined

I'm sure many of you who are here from out of town have already cast your absentee ballot for tomorrow's election. Regardless of the election outcome, one of the top priorities for USDA will be to continue to help American farmers maintain competitive status in world trade. And as we know, the impending ban on methyl bromide threatens that status.

Most of you are aware that the Montreal Protocol of 1991 defined methyl bromide as a chemical that contributes to depleting the ozone layer. As a result, the U.S. Environmental Protection Agency, under the Clean Air Act, expects to phase out use and production of methyl bromide by January 1, 2001. This phaseout is much more restrictive than the one most other countries plan to follow. At a December 1995 meeting in Vienna, parties to the United Nations' Montreal Protocol on Substances that Deplete the Ozone Layer agreed to eliminate use of methyl bromide in industrialized countries in 2010. This phaseout date will be preceded by a 25-percent cut in 2001 and a 50-percent cut in 2005. Under the agreement, developing countries will freeze methyl bromide use in 2002. However, these actions will have no bearing on the total phaseout in the United States on January 1, 2001.

USDA Recognition of the Magnitude of the Potential MeBr Ban

We recognize at USDA that methyl bromide is critical to American agriculture. U.S. growers use it extensively to fumigate the soil before planting to control plant pathogens and weeds and to treat harvested crops to satisfy quarantine requirements. It is also used to fumigate structures such as grain warehouses, flour mills and ships carrying agricultural commodities. Deputy Secretary of Agriculture Richard Rominger said last year that unless viable alternatives to methyl bromide are found, U.S. farmers will be at a distinct disadvantage in domestic and international agriculture and trade when the ban takes effect. He stressed that USDA supports legislation that would prevent our farmers from being placed at a competitive disadvantage, yet recognizes that developing

effective, economical alternatives to methyl bromide is in the best long-term interest of agriculture.

The Deputy Secretary also said that a major research effort is necessary to ensure that American farmers can continue to raise and market their crops.

Potential Impact of the Ban

In addition to this policy position from the Secretary's Office, the General Accounting Office, a unit of Congress, issued a December 1995 report stating that because methyl bromide is an important pesticide worldwide, a ban that takes effect in the United States before being implemented in other countries could create an "uneven playing field" in international trade for U.S. producers. The need to use more costly and/or less effective alternatives could increase costs and reduce yields for growers of U.S. crops. In addition, some countries require certain U.S. commodities to be treated with methyl bromide as a condition of entry. These markets would likely be lost unless acceptable alternatives could be agreed upon with the importing countries. Here in the United States, we also regularly require a methyl bromide treatment for many commodities imported from other countries.

The ban on methyl bromide will hit Florida and California growers particularly hard. Florida fruit and vegetable growers will lose more than $600 million annually for the winter growing season alone. Total sales loss would exceed $1 billion and more than 13,000 jobs would be lost. These estimates do not include the monetary value of losing methyl bromide as an emergency postharvest treatment to move commodities from a quarantined area in the event of an invasion of fruit flies or other serious pests. Methyl bromide is now the only effective treatment.

Anticipated losses in California are just as overwhelming. University of California researchers estimate that, in the short term, the loss of methyl bromide would reduce net farm income in California by more than $288 million annually. Growers of strawberries, nursery products (such as cut flowers and roses, fruit, vine, nut and strawberry plants) and grapes would suffer the greatest losses. California's fresh fruit and dried nut crops would suffer because any other fumigation method would cost more and take longer. Walnut producers stand to lose about $36.8 million annually; cherry growers, $7.3 million. More holiday walnuts would go from export to domestic markets because alternative techniques could not be used quickly enough for the holiday export market. Similarly, cherry producers export their best fruit; the loss of methyl bromide would divert that market to the domestic market.

ARS Response to the Crisis

Regarding USDA research, a major effort is well underway at 18 ARS laboratories throughout the country, where we have about 41 scientist-years devoted to the methyl bromide issue. Of the $14.7 million Congress appropriated for ARS methyl bromide research in fiscal year 1997, $7.1 million (48%) is allocated for soil fumigation work and $7.6 million (52%) for postharvest. These totals include a $1 million increase received this year which is being used to expand our research in California and Florida on preplant fumigation alternatives for soilborne diseases of

strawberries, vegetables, and perennial crops, including grapevines, fruit trees, and nut trees.

Since the beginning of our methyl bromide research program in 1993, ARS has invested more than $1.5 million to support research by university scientists seeking alternatives to methyl bromide.

ARS Accomplishments

Because we believe no single alternative technology will likely replace methyl bromide, we are making progress on a broad front in order to develop a portfolio of choices and combinations tailored for specific needs.

As alternatives to soil fumigation, we're working on biocontrol, host-plant resistance, alternative chemicals, and cultural practices to control soilborne pests and diseases. Examples of recent progress:

Soil Fumigation

Biocontrol:

- Identifying increased uses for SoilGard™, now commercially available to fight soilborne fungal diseases

- Developing non-pathogenic *Fusarium* isolates that show promise in managing disease caused by pathogenic *Fusarium*

Host-Plant Resistance:

- Progressing on work to genetically build in nematode and pathogen resistance in plums, grapes, peaches, and other crops

- Developing transgenic tomatoes containing genes that interrupt nematode feeding

- Getting ready to release pepper varieties containing nematode resistance found in pepper germplasm

Alternative Chemicals:

- Using methyl iodide successfully as an effective alternative in several systems

- Getting good control with other combinations of registered chemicals

Cultural Practices:

- Controlling weeds in vegetables effectively with solarization.

Heretofore-unidentified problems will probably develop when methyl bromide is withdrawn. In many cases, finding alternatives while we're still using methyl bromide is complicated because we're not sure what disease problems will arise when it's no longer available. However, we've made important progress in identifying what may be expected for diseases of almonds, carrots, strawberries and apples when replanted.

Postharvest

For 50 years USDA has used the somewhat arbitrary statistical standard called Probit 9 to define the acceptability of a technology to achieve quarantine security. Probit 9 requires a pest kill rate of 99.9968 percent. However, a treatment based on Probit 9 may be too severe for commodities that are not heavily infested with a pest insect or disease, and may be too rigid,

impractical, and unnecessary in many cases. ARS has been working with APHIS policy officials and representatives of foreign governments to develop alternative standards based on pest risk rather than the rigid, prescriptive requirements for quarantine security of Probit 9. We're considering a holistic approach—production to consumption—rather than focusing entirely on postharvest treatment. This approach, combined with a sliding-scale concept, allows a more realistic evaluation of pest risk and pest risk management options. It also provides many more opportunities to identify new treatments and innovative approaches to treatment.

One of those opportunities involves ARS scientists in Hawaii using irradiation as an alternative for achieving quarantine security for papaya, carambola, and litchi. Working with APHIS, we have proposed several amendments to the requirements for irradiation procedures and facilities and the handling of treated and untreated fruits and vegetables. This would speed interstate movement of papaya, carambola, and litchi from Hawaii while continuing to protect other parts of the United States from Hawaiian pests.

Another recent postharvest success is a newly developed quarantine procedure for compressed hay to be exported to Japan. Others include the following:

- Using gamma irradiation to effectively disinfest exotic fruits and blueberries
- Completing a forced hot-air quarantine protocol for medfly in California grapefruit and other citrus
- Using phytotoxic dyes to control fruit flies
- Transferring a highly competitive new strain of medfly to APHIS for sterile release control program.

External Cooperation

ARS is committed to ever strengthening our relationship with industry and university partners in our search for methyl bromide alternatives. We've been working closely with the California Strawberry Commission and other members of the Crop Protection Coalition and the University of California in a validation project in California testing possible alternatives to methyl bromide at field-scale crop production levels. In Florida, our collaborators on similar field-scale research are the Florida Fruit and Vegetable Association and the University of Florida.

In California, a team of experts including scientists, extension personnel and growers has been assembled for strawberries and for perennial crops. These teams will test cropping systems that have the best chance of becoming alternatives to methyl bromide. On small test plots, research has shown 1,3,D/chloropicrin to be an effective replacement for methyl bromide fumigation. To test this under a range of grower conditions, field plots will be set up in the Watsonville/Salinas area, Santa Maria, along the southern coast, and in the central valley. Most of the commercial strawberry production in California is along the central and southern coast. We'll repeat the field validation experiments on the same plots for 3 years to minimize effects from past use of methyl bromide. Alternative application methods that can result in reduced chemical use and

emissions—such as bed fumigation and alternative plastic mulches—will also be used to determine practicability, acceptability, and cost.

Other practices being tested in these California field studies include alternative fumigants and reduced rates and application methods, improved mulching practices, crop rotations and fallow, and improved water and fertility management.

In Florida, we have used two plastic mulches that suppress nutsedge, one of the 10 most common and troublesome weeds in vegetable crops. Few chemicals other than methyl bromide are available to control nutsedge. Both photoselective, infrared-transmitting mulch films and silver mulch films were used in both greenhouse and field experiments and significantly suppressed purple nutsedge. We don't know yet just how these mulches work with respect to their effects on the photochemistry of the weed plant, but more research is planned.

Activities of Other USDA and Outside Agencies

USDA's Forest Service (FS) has responded to the methyl bromide crisis by re-establishing nursery research programs at Athens, GA, and St. Paul, MN. Scientists there are working on integrated pest management programs that will produce high-quality tree seedlings. Along with the Foreign Agricultural Service and APHIS, FS researchers have successfully negotiated to get U.S. heat-treated coniferous wood accepted into Europe and kiln-dried lumber into Korea. In the past, methyl bromide has been the treatment used for quarantine pests of logs and other wood products.

We're also meeting with EPA to review and resolve registration issues for potential chemical replacements for methyl bromide. One concern is: Will companies come forward to register these new chemicals? And, is an alternative "viable" if it hasn't been registered with EPA or if there are no prospects for registration? We're discussing these issues as well as updates to recent legislation such as modifications to FIFRA or other laws that affect recapturing, recycling or reducing the release of methyl bromide into the environment.

In addition to our work with EPA, Dr. Horn has been personally involved in fostering the establishment of a joint U.S. partnership with Israel. Under this venture, the United States and Israel are each offering $600,000 for competitive grants research that will benefit both countries in the quest to find alternatives to replace methyl bromide, reduce or contain emissions, and improve application of the fumigant. Through collaboration, we found that Israel has problems with the loss of methyl bromide that are very similar to those in the United States. Scientists at the Volcani Center in Israel are conducting research to improve the technology of soil solarization. They're also trying to reduce emissions of methyl bromide by using gas-tight films and seeking improved ways to administer the chemical. One of the most promising approaches being tried in Israel is the use of microorganisms, like *Trichoderma* and nonpathogenic strains of *Rhizoctonia*, to biologically control soilborne pathogens.

On the U.S. side, this grants program is being administered by the U.S. Department of Commerce. A Request for Proposals (RFP) has

been published and details are available on the Internet as well as in the October 1996 issue of the USDA ***Methyl Bromide Alternatives*** newsletter. Applications for support under this venture must be made by December 31; funds will be awarded by the middle of February 1997. An important note is that research selected for funding must define a plan for commercialization within 48 months after the work begins.

The USDA ***Methyl Bromide Alternatives*** newsletter is now online. In fact, we have a poster session tonight to demonstrate our methyl bromide research web site as well as all five issues of the newsletter, including the new October 1996 issue. Incidentally, this new issue was mailed out last week. As you know, we started this newsletter last year to keep the agriculture community up to date on what researchers are doing.

In closing, let me reaffirm USDA's dedication to help find a practical way to keep agriculture alive, worldwide, with acceptable methyl bromide alternatives. I hope this conference represents another important step in that direction. Many of the research approaches and reports of progress that I only briefly mentioned today will be discussed in much more detail by other speakers over the next three days.

Thank you once again for inviting me to share USDA's perspectives with you.

Upcoming Meetings

Tel-Aviv, Israel—March 9–15, 1997

The International Congress for Plastics in Agriculture (CIPA) will be held at the Dan Panorama Hotel in Tel-Aviv, Israel, March 9–15, 1997. Discussion will focus on using plastics in the following areas:

- Protected cultivation
- Soil disinfestation
- Irrigation and novel uses
- Packaging of agricultural commodities
- Environmental considerations.

In addition to scientific discussions on these topics, the conference will include 2 days to tour factories and observe field demonstrations. For more information, contact Shimshon Ben Yehoshua, president of CIPA: e-mail: (VTCIPA@volcani.agri.gov.il); FAX 972–3–9683622.

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

This publication reports research involving pesticides. It does not contain recommendations for their use nor does it imply that uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact the USDA Office of Communications at (202) 720-2791.

To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, DC, 20250, or call 1-800-245-6340 (voice) or (202) 720-1127 (TDD). USDA is an equal employment opportunity employer.